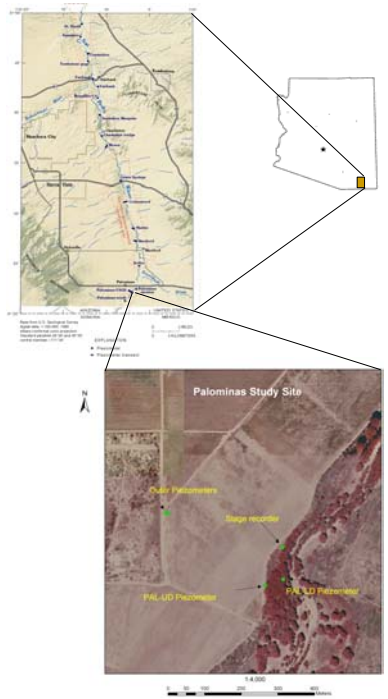
A Multiparameter Approach for Measuring Flood-Induced Aquifer- and Bank-Storage Changes Along the San Pedro River, Arizona

Introduction

The San Pedro Riparian National Conservation Area (SPRNCA) is a federally protected area in Cochise County, Arizona, USA. Base flow in the San Pedro River and shallow depths to ground water in the flood-plain aquifer are essential for maintaining the health of the riparian system within the SPRNCA. These elements are potentially threatened by pumping of regional ground water for residential and municipal use.

Direct recharge to the flood-plain aquifer during high flows of the San Pedro River may be an important factor in maintaining base flow through subsequent dry periods (Pool and Coes, 1999). This study was designed to measure the storage of water in the flood-plain aquifer and river banks during high-stage events and to determine the duration of increased flow supported by the release of stored water.



Approach

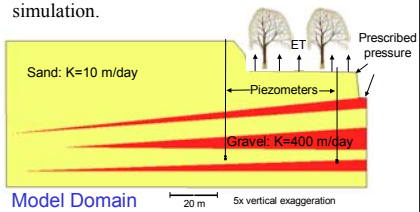
One of 16 established study sites (Palominas) along the San Pedro River was selected for a detailed study of stream-aquifer interactions and bank-storage during the summer 2001 monsoon season. This site differs from the perennial site examined by Whitaker (2000) in that the river flows intermittently in response to climatic conditions.

Hydraulic and geochemical approaches were applied to determine streamflow infiltration from flow events during summer and fall 2001. Continuous hydraulic data were collected from seven piezometers and one stream-stage recorder. Water sampled from three piezometers and the stream was analyzed for $\delta^{18}O$, δD, major ions, pH, conductivity, and SF_6. Continuous temperature was monitored in piezometer PAL-LD at nine depths.

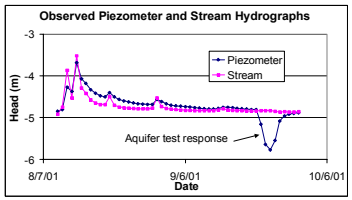
The USGS variably-saturated simulation software, VS2DHI, enabled the synthesis of water-level data into a comprehensive model of bank-storage response to stage changes. Values of $\delta^{18}O$ obtained from well and river samples enabled calculations of mixing percentages between flood water and ground water in the flood-plain aquifer.

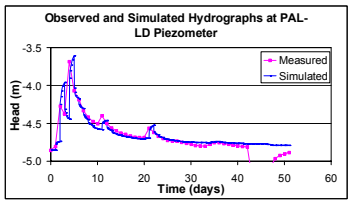
Simulation

The simulation assumed bilateral symmetry and only considered the left bank. Measured river stage served as the input boundary and the simulation was calibrated to observed piezometer hydrographs. Cores collected during drilling dictated the layered sand and gravel used in the simulation.



Observed stream and piezometer hydrographs show that head in the stream alluvium remains elevated above stream stage for about 36 days following major flow events.





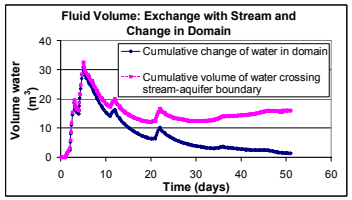
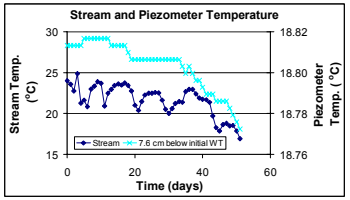
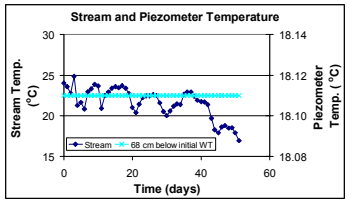


Table of simulated bank-storage volume in model domain and at watershed scale.

Parameter	Volume (m^3)
Model domain release to stream without ET	36
Transpiration	16
Model domain release to stream with ET	20
Total streamflow	11,707,772
Scaled model release	1,600,000
Total streamflow following gradient switch (toward stream)	1,800,000

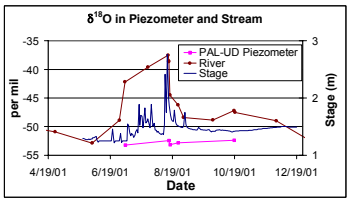
Temperature was monitored in a vertical array in the near-stream piezometer for use as a tracer of flow. No response to floodwater was observed at 68 cm below initial water-table elevation





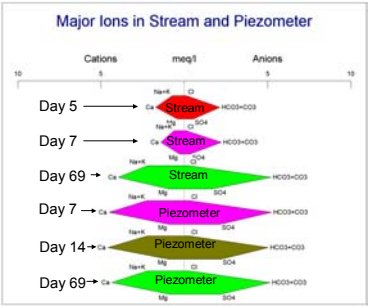
Chemical Parameters

Samples for $\delta^{18}O$ and δD in PAL-UD show slight response to river input.



Mixing calculation using $\delta^{18}O$ shows that water collected from PAL-UD did not exceed 5 percent floodwater.

Stiff diagrams of major ions shows no appearance of floodwater in PAL-UD and full return of streamwater to ground-water signature.



Conclusions

- Bank storage in summer 2001 contributed to base flow for approximately one month after flood recession.
- Numerical simulation successful at replicating observed heads.
- Match obtained between scaled-simulated bank-storage release and measured flow past site during study period.
- Observed temperature profile suggests virtually no downward infiltration – only lateral movement.
- Analyzed chemical data at PAL-UD suggest little movement of floodwater to piezometer screen, but head at piezometer was responsive.

References

Pool, D.R., and A.L. Coes, 1999, Hydrogeologic investigations of the Sierra Vista subwatershed of the Upper San Pedro Basin, Cochise County, southeast Arizona: U.S. Geological Survey Water-Resources Investigations Report 99-4197, 41 p.

Whitaker, M.P.L., 2000, Estimating bank storage and evaporation using soil physical and hydrological techniques in a gaining reach of the San Pedro River, Arizona: Tucson, University of Arizona, Ph.D. dissertation, 232 p.

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